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Our goal is to develop an analytical and numerical approach to diagnose arrival sound waves from long-distanced sources on the basis of the most advanced methods of dynamics that include ray dynamics, wave dynamics reconstruction on the basis of ray dynamics, specific asymptotic solutions in the short-wave approximation, and specific diagnostic codes adjusted to the wave-chaos analysis.

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Wave Chaos and Chaotic Transmission of Waves

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LONG-TERM GOALS

Our goal is to develop an analytical and numerical approach to diagnose arrival sound waves from long-distanced sources on the basis of the most advanced methods of dynamics that include ray dynamics, wave dynamics reconstruction on the basis of ray dynamics, specific asymptotic solutions in the short-wave approximation, and specific diagnostic codes adjusted to the wave-chaos analysis.

OBJECTIVES

Long-range sound propagation in ocean can be studied using contemporary methods of nonlinear dynamics, resonance theory, theory of chaos and, particularly, quantum chaos.

Our research is directed towards developing and understanding of new phenomenon: wave-chaos. The Results can be applied to wave propagation in plasma layers and toroidal plasma devices, to mesoscopic systems (electron transport and conductivity of quantum wires and dots).

APPROACH

In our research we use:

1. WKB-method
2. Topological analysis of chaotic orbits in the phase space
3. Kinetic theory and fractional kinetics
4. High-performance simulations

WORK COMPLETED

It has been demonstrated that the mechanism of emergence of ray chaos due to overlapping of nonlinear ray-medium resonances should play an important role in long range sound propagation.

We considered quantum breaking time scaling in superdiffusive dynamics.

We considered weak mixing and anomalous kinetics along filamented surfaces.

RESULTS

The properties of ray travel times, including fractal properties of the timefront fine structure, under condition of ray chaos have been investigated. It has been shown that coexistence of chaotic and regular rays, typical for dynamical chaos, leads to the appearance of gaps in ray travel time distributions, which are absent in unperturbed waveguides.

We demonstrate by simulation that quantum breaking time scales as $\tau_\hbar \sim (1/\hbar)^{1/\mu}$ with $\mu > 1$ that corresponds to superdiffusive dynamics.

We showed that in a square billiard with a horizontal bar in the middle the transport is anomalous and that its properties can be linked to the ergodic properties of continued fractions.

IMPACT/APPLICATIONS

General theory of wave propagation in waveguides.

REFERENCES

1. “Theory and application of ray chaos to the underwater acoustics” by I.P. Smirnov, A.L. Virovlyansky, and G.M. Zaslavsky (Published in Phys. Rev. E, Vol. 64, 036221 (2001))

2. “Quantum breaking time scaling in superdiffusive dynamics” by A.Iomin and G.M. Zaslavsky (Published in Phys. Rev. E, Vol. 63, 047203 (2001))

3. “Weak mixing and anomalous kinetics along filamented surfaces” by G.M. Zaslavsky and M. Edelman (Published in Chaos, Vol. 11, pp. 295-305 (June 2001))